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Effects of global changes on ecosystems services of multiple natural resources in mountain agricultural landscapes

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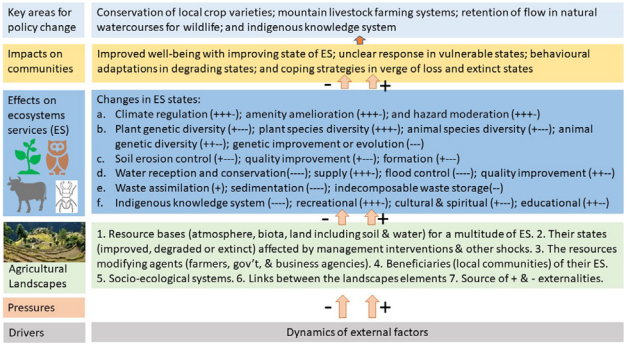
HIGHLIGHTS

- Positive changes on climate regulation, amenity amelioration and hazards moderation.
- Declined native species and genetic diversity but enriched wildlife habitats.
- Increased soil conservation but reduced soil quality and soil formation opportunity.
- Negative effect on water conservation but mixed effect in water quality and supply.
- Declined knowledge system & spiritual but surged recreational services.

GRAPHICAL ABSTRACT


Key areas for policy change
Conservation of local crop varieties; mountain livestock farming systems; retention of flow in natural watercourses for wildlife; and indigenous knowledge system
Impacts on communities
Improved well-being with improving state of ES; unclear response in vulnerable states; behavioural adaptations in degrading states; and coping strategies in verge of loss and extinct states
Effects on ecosystems services (ES)
Changes in ES states:
a. Climate regulation (+++-); amenity amelioration (+++-); and hazard moderation (+++-)
b. Plant genetic diversity (+---); plant species diversity (+++-); animal species diversity (+---); animal genetic diversity (++--); genetic improvement or evolution (---)
c. Soil erosion control (+---); quality improvement (+---); formation (+---)
d. Water reception and conservation(----); supply (+++-); flood control (----); quality improvement (++--)
e. Waste assimilation (+); sedimentation (----); indecomposable waste storage(--)
f. Indigenous knowledge system (----); recreational (+++-); cultural & spiritual (+---); educational (++--)
Agricultural Landscapes
1. Resource bases (atmosphere, biota, land including soil & water) for a multitude of ES. 2. Their states (improved, degraded or extinct) affected by management interventions & other shocks. 3. The resources modifying agents (farmers, gov't, & business agencies). 4. Beneficiaries (local communities) of their ES. 5. Socio-ecological systems. 6. Links between the landscapes elements 7. Source of + & - externalities.
Pressures
Drivers
Dynamics of external factors

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ABSTRACT

Ongoing global changes can make unprecedented alterations in the state of some natural resources and their ecosystems services (ESs), especially in mountain agricultural landscapes. Considering the risk suggested by the Millennium Ecosystems Assessment, this study collected descriptive (qualitative) data in Nepalese mountain farming communities through field observation, group discussion, and personal interview, and investigated changing conditions of ESs of various natural resources in agricultural landscapes and their repercussions on mountain communities. The results showed that global changes induced new resources and institutions for mountain farming practices and altered important socioecological processes determining ESs. They have contributed to reductions in natural hazards and climate change and improvements in recreational and waste management services in mountain farming landscapes. Biodiversity status changes of the external factors in the agricultural landscapes are mixed: reasonably enriched plant species diversity and wildlife habitat, and seriously degraded or extinct indigenous species and genetic diversity. One of the serious negative changes is they have contributed to extinction of locally adaptable natural capitals and community heritages that had been developed through century-long socioecological processes and passed through extreme climatic variabilities and other environmental stresses at numerous times. The study determined that some recently emerging local biotic conditions result mainly from changes in the condition of water resources, not from changes in climatic conditions. The external factors also hampered human input into soil formation in degraded lands, soil quality, soil-water conservation and local knowledge systems. Overall, the effects of the changes found mixed on human and environment health. This multiple natural resources-based study has contested some arguments and conclusions of popular literatures.

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1. Introduction

Agricultural landscapes of developing mountain societies contain many natural resources (hereafter 'resources') which provide a range of ecosystems goods and services (ES) with both local and global values (Grêt-Regamey et al., 2012; MEA, 2005). Literally it is a mosaic of farming fields and surroundings where ongoing human actions moderate or modify various natural resources for farming and other wellbeing purposes. In ecosystems context, the landscape encompasses several factors and phenomena: Resource bases (atmosphere, biota, land including soil elements and water) of multitude of ES; their states (improved, degraded or extinct) get altered by management interventions and other shocks (e.g. climate change, technology innovation, communication networks and international economic development policy reform); modifying agents (farmers, government and business agencies) of the resources; beneficiaries (local community including farmers) of their ES; links between the landscape elements; social-ecological systems or processes resulting in ES; and source of externality (positive and negative). The mountain landscapes contain remnants of the resources that were developed through centuries' old coevolution processes of social and ecological systems as the mountain people improved with local management for increasing availability, access, uses and stability and adapting against harsh terrains, natural disasters, socio-political crises and economic recessions. These precious resources have considerable strengths of providing backups to the modern farming resources which have risks of serious failure and requirments for external inputs. Developed countries and many other communities have regrettably lost such resources after unmanaged industrial revolution (Robinson and Sutherland, 2002).

However, some of the mountain resources in the agricultural landscapes are very sensitive to degradation to extinction. It is due to fact that the resources are managed by the communities who have been living and doing farming in harsh and geophysical weaker locations. Huge changes are undergoing in their living conditions and localities due to changes in national and international factors (Ojha et al., 2017; Gartaula et al., 2012; Korner et al., 2005a; MEA, 2005). They require conservation actions to maintain ecological and economic vitalities and wellbeing of both mountain communities and downstream societies (Duprez, 2016; Ives, 2004). Improved management of the resources can also contribute to addressing other growing global problems (e.g. greenhouse gas emission) and demands (e.g. recreational). An in-depth study on undergoing conditions of the natural resources and their repercussions to local communities may help stakeholders to make informed decisions on managing the precious resources for the wellbeing of vulnerable local people and benefit of downstream communities.

The state of natural resources and their ESs in mountain agricultural landscapes, particularly those of developing countries, are rarely studied on a regular basis or in detail though its updated knowledge is importance for securing livelihood of the vulnerable people. The Millennium Ecosystems Assessment also assessed conditions and problems of general mountain resources only at a high level and suggested undertaking in-depth community level studies (Korner et al., 2005b). The focuses and explanations of international agencies that have studied on natural resources problems in the mountain areas, are driven by values, perceptions and interests of distant beneficiaries and stakeholders (Wester et al., 2019; Ives, 2004). A few field based studies have investigated emerging environmental problems by climate change at community level, but they focused on changes in conditions of a few resources and ended up with controversial conclusions (Gentle et al., 2014; Chaudhary and Bawa, 2011). The arguments of some studies that recent agricultural practices of mountain farmers escalated climate change are also controversial (McDowell et al., 2019; IPCC, 2014; Xu et al., 2009a; Xu et al., 2009b; Venkataraman et al., 2005). The contestable findings and arguments are widely perpetuated. Studies on emerging ES problems resulting from changes in the condition of other resources through the lens of a multiple resources framework could help to resolve the debatable issues. The effects of some farming practice changes on ESs in mountain agricultural landscapes particularly in developing countries could be also different from the findings in other areas (Stoate et al., 2009; Zhang et al., 2007; Tscharntke et al., 2005). Previous studies had not well investigated the differences. In addition, previous studies poorly accounted field level dynamics of interactions between social and ecological processes that determine many ecosystems services of natural resources of mountain farm lands (Korner et al., 2005a). Our study attempted to address the issues lacking in previous studies.

The main purpose of this study is to improve understanding of mountain resource management problems. The study worked with the following specific objectives to achieve the purpose.

- To describe changing trends in the condition of multiple main natural resources within agricultural landscapes;
- To determine negative changes in main locally important ecosystems services of the resources;
- To identify problems experienced by mountain communities associated with the changes in the ecosystems services.

To achieve these objectives, this study evaluated numerous ecosystems services under broad environmental resource groups: atmospheric environment, biodiversity, soil, water and waste sink. The study considered multitude of resources and ecosystems services in agricultural landscapes based on the assumption that an investigation of conditions of all possible interrelated and overlapping nature of ecosystems services would make it easier to detect the main drivers, mechanisms and their associated problems and reduce flawed conclusions. It is hypothesised that some emerging factors have hampered provision of ecosystems services of some natural resources to a serious extent and resulted in some negative impacts on local communities.

2. Study site

2.1. Physical description of study site

This study was based on the data of agricultural landscapes in Nepal's Marshyangdi River catchment in Lamjung district, Nepal. The location of study site is illustrated in Fig. 2.1. The locality extended from 300 to 3500 m above sea level. According to CBS (2016), the average total annual rainfall of this region is about 3400 mm, but over 80% occurs in July, August, and September. Extreme rainfall and landslides are common phenomena in the mountains during the high rainfall season.

Fig. 2.2 shows a wider view of a mountain agricultural landscapes in the study site. In the mountain context, the agricultural landscape is not exclusive of privatized land. People from the region were settled and farmed in environmentally safer localities which are sparsely distributed in the mountain landscape. The lands considered environmentally less safe were managed communally and used for forest or grazing purposes. The people practised crop-livestock mixed farming in the moderately marginal lands and valleys; forest resources-based crop-livestock mixed farming in mid hills and extensively livestock-based farming in the high-hill region (Dhakal et al., 2011; Ives, 2004). More than 60% of farmers hold less than 0.5 ha which is barely sufficient to feed a livestock unit. Therefore, the mountain agricultural landscape is a mosaic of private farms, community grazing lands and forests.

Lowland rice crop is grown over 60% of the land area of the catchment where the rainfall provides a seasonally irrigational facility. Other upland areas during the season are used for millet, horticulture, grass and residential purposes. Most of the millet and lowland rice growing areas are occupied by maize crops during the summer season whereas fallowing is followed by vegetable crop during winter season.

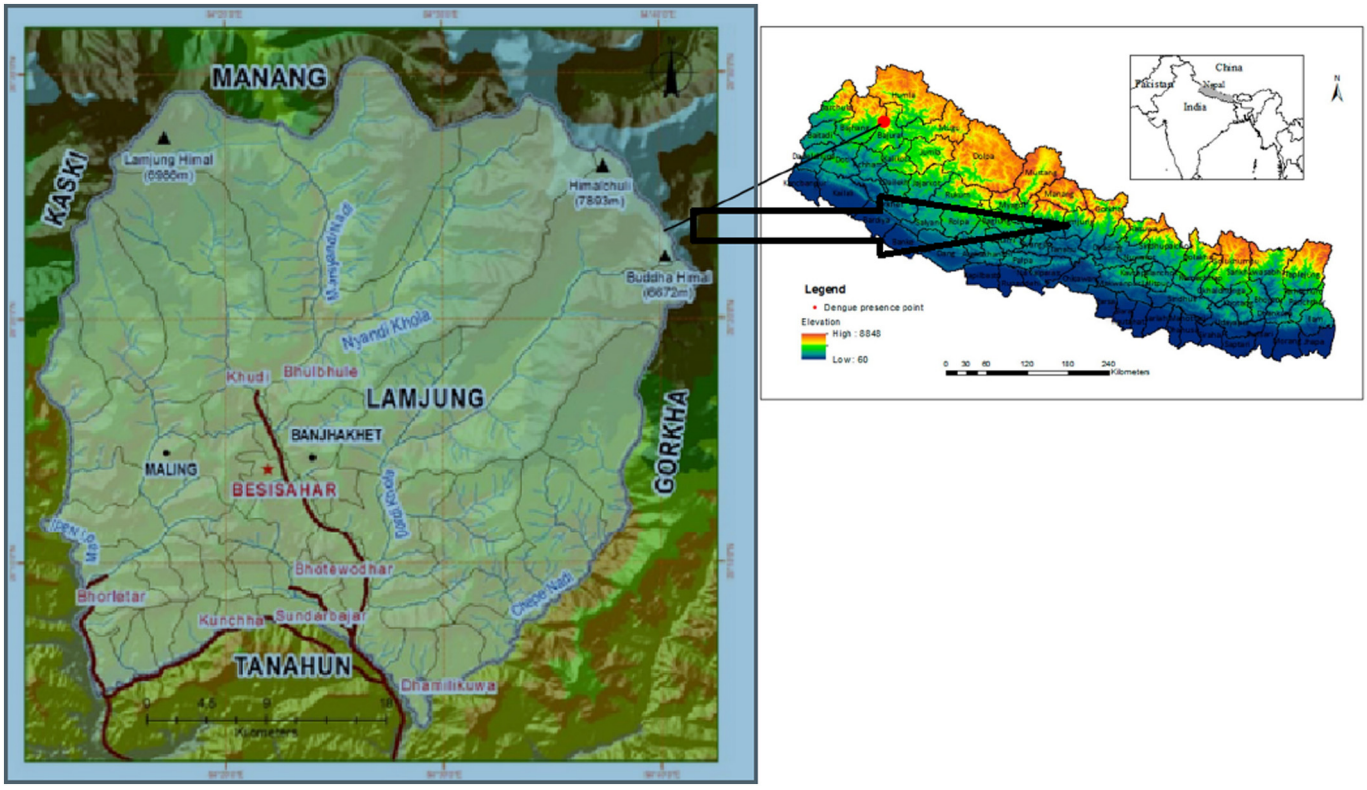

Fig. 2.1. Map of study site.
[Source: Shrestha, 2014]

2.2. Local resources, practices and conditions determining ecosystems services

The major farm activities making difference in Greenhouse Gas (GHG) emission in this study areas include fertilizer application, rice farming, household energy use and livestock farming. Increasing vegetation in farmland is the main farm activity for mitigating GHG. Commonly improvement in vegetation, smoke management and tilling activities moderate local atmospheric phenomena and improve ambient air quality. Vegetation, livestock and soil management can moderate natural hazards.

Fig. 2.2. A wider view of a mountain agricultural landscapes.

Nepal has become a home of 172 families, 294 genera, and 551 species and subspecies of agricultural crops within 118 agro-ecosystems (CBS 2016 and 2008). Nepal, area-wise a small country, a home of about 200 cultivated species and 120 wild relatives of the commonly cultivated food plants out of over 5000 plant species (MoSFT, 2014). In the old days, the farmers cultivated many kinds of plant species by utilizing microclimatic variations in mountain landscapes which enabled them to be survived in the harsh topographic conditions. Mountains farmers selected and reproduced adaptive lines of plants species based on local environmental feedbacks over many generations of practice. The interactions of human management and mountain climatic diversities contributed to development of many races such as 680 of rice, 713 of finger millet, 322 of barley, 216 of soybeans, 184 of buckwheat, 146 of lentil, 35 of bean and 102 of oil-crops.

According to official statistics (CBS, 2008), Nepal is the home of 24 typical local breeds of cattle, buffalo, sheep, goats, pigs, and poultry but some of the animal breeds are either extinct, (e.g. pure breed of Siri cattle) or are threatened to extinction (e.g. Lulu and Achhame cattle, Lime buffalo, Lampuchhre and Kage sheep, and Bampudke, Chwanche and Hurrah pigs). The mountain farmers domesticated multipurpose animals with diverse genetic resources and became adaptive to the harsh topographic conditions. The animals are characterised by small body size, well-developed feet for walking in the hilly terrain and an ability to thrive in naturally grown pasture and cope with nutritionally poor-quality feed. Livestock are main sources of manure, milk and meat production and farm power (ploughing). They are also a means for carrying goods in the communities with no road service.

Land gradient (slopping ground) and underground forces (colliding pressure of Indian and Tibetan plates) have placed the mountain farming land and soil in a fragile state with an enhanced risk of sliding or eroding (Ives, 2004). Farm practices could modify land surface and soil binding properties, reduce forces of eroding agents (wind, rainfall, runoff and flooding) and help in retaining soil nutrients and other

materials for nursing and anchoring of plants. Maintaining soil quality is of much importance in mountain farming land, due to high potential of plant nutrient loss by soil erosion and underground leaching associated with a steep land gradient. Farm activities could alter the soil condition (in terms of retaining nutrients and other supporting materials), nutrient compositions and functional properties (filtering, decomposing, buffering of organic and inorganic materials and regulating flows of water and other solutes to plants) essential for sustaining, enriching and thriving biota (Lal, 2014). Geophysical conditions result in continuous passive loss of farming soil from almost all mountain farming lands. In addition, landslides and stream meandering wash out and cover the farming soil. Certain farming practices can facilitate a rapid recovery and restore biologically productive soil.

Mountain farm structures and practices have some special attributes that could make substantial differences to the amount of water received, in-filtering and conserving during precipitation, collected from runoff and from artificial application activities (Lal, 2014; Ives, 2004). Water availability for the mountain communities varies greatly with season and geophysical condition of locality (Ives, 2004). The rainfall pattern plays a key role in water flow from springs and streams in mountain areas. In addition, land management practices can also make differences to the retention and distribution of water flows in different spaces and times and contribute to enriching and sustaining diversity (Calder and Aylward, 2006; MEA, 2005). Farmers engage in a range of activities on their land which can change the biological, chemical and physical properties of water in the farm and downstream. These properties determine ecosystem functioning of local systems, and the health of animals, aquatic systems and humans.

Farmland can be considered both a source and a sink of waste. It can decompose and detoxify the waste materials produced in household, urban and industrial sectors. Application of the waste at scientifically-recommended doses, methods and sites could reduce the toxic effects to human and environmental health and bring some benefit to the farmers. Natural events and human activities produce a lot of sedimentation materials which need to be reduced or settled upstream for reducing stream loads and their damage to build-infrastructure, settlement, and farmland in downstream parts of the river (Ives, 2004). Land management practices and structures for stabilizing the soil provide some barriers against moving debris and soil coming with landslides and/or suspended in floods. Some unperishable and slowly decomposing waste materials can be stored on farmland.

Mountain communities have made their living on various natural resources for centuries and developed some specialized local skills and knowledge (hereafter 'indigenous knowledge') for addressing human and environmental problems. This knowledge is still useful in those communities where modern techniques, products or development services are costly, unavailable or ineffective (Sharma et al., 2009). However, it can be of little help to needy people unless the indigenous knowledge system remains functional: practising regularly within the community, updating to the changing local context and sharing with the next generation. Mountain communities identified, developed and managed diverse ecological resources and practices and sustained their lives in harsh topography for centuries. The resources management knowledge that the people have retained is considered helpful in identifying social, environmental and health problems and solutions for other areas (Briggs, 2005; Ives, 2004). The resources are often considered hidden treasures because many merits of the mountain resources are under explored. Some farmers use dynamics of natural resources of the lands to predict weather conditions (e.g. ant behaviour for rainfall).

Some local resources (e.g. plants, animals, land sites, mountains, and water sources) have been used in social events and festivals for generations and have acquired important cultural significance and identity (MEA, 2005). Intimate connections of the lives of mountain communities to the natural environment have contributed to developing and strengthening their beliefs and behaviours. Some of their beliefs and behaviours have acquired spiritual values and have been considered sacred. This is because using the resources in their cultural ways contributes to addressing the beliefs of practising communities and relieving them from psychopathological problems.

Mountain agricultural resources are wonderful sources of amenity and recreation for tourists for thrilling with amazing views of terraced farming, agroforestry landscapes and crop-mixed patches in the mountain landscapes. Tourists and local people can enjoy with romantic songs, fights, dances, and other movements of the animals and other creatures hosted by the landscapes. The mountain agricultural resources provide recreational attraction to the people who are least interested in costly, risky and long-distance activities such as national parks and water sports.

3. Materials and methods

3.1. Data

Precise measurement of the dynamics of natural resources and ecosystems is a complicated task. It requires measuring changes in the stocks of the resources and flows of their goods or services in reference to baseline data. The farm level baseline data are rarely available in developing countries. Collecting some data of changes in the conditions of natural resources and their ecosystems services requires considerable discussions in groups or supplementary questions depending on resource or ecosystem types. These problems guided this study to follow a multi-approach qualitative method. This study used the following traditional measures to collect the data.

a. Transect walk across landscapes;
b. Group discussion;
c. Personal interview,
d. Some secondary sources of information.

Transect walks were done across different farming land areas of different altitudes and topographical aspects and discussed with mixed-age people individually and in groups. Help of some local people were taken to confirm observations from the transection walks. The main objective of transect walks was to collect data of natural marks and other physical changes in the landscapes caused by recent factors. The information also helped to guide specific points in group discussion and personal interview. Landowners were contacted in some sites where interesting changes had occurred. Researchers visited some communities in multiple seasons specially to observe land use changes and observe seasonal activities. Focus group discussions were conducted to identify the emerging resource management problems that the majority of respondents could answers in the individual interviews. The focus group method was used to collect data on historical changes of natural resources at community level and to get the data that require confirmation from multiple individuals. Readers can easily know the information collected through this method while reading main text in the result section. Researchers visited 14 study communities and discussed with people multiple times. The members in group discussion ranged from 3 to 8 people depending on their availability. A semi-structured interview with open-ended questions was conducted with local farmers, most of whom were elderly (both males and females). The respondents were contacted mostly by household visits and some in community gatherings. The personal interview method was used to collect individual's experience or household related information. The number of interviewees ranged from 3 to 9 people in each community depending on size of community. Due to requirement of collecting data of many kinds of natural resources and relatively large household communities (ranging from 8 to 49 households in a community), the sample represented less than 1% of the study population.

The order of asking main survey questions in personal interviews was the same for all resources. The questions were modified as required

to fit the nature of the individual resource or service and answering convenience of respondents. These modifications can be seen in the results section. The respondents also gave a substantial number of incomplete and irrelevant answers to the questions they were asked. Therefore, supplementary questions were asked following main questions for getting meaningful answers. The framework of main questions that were asked of respondents for each kind of natural resource were as follows:

a. What are the changes that you have experienced or seen in the conditions of given resource (e.g. plants, animal, soil and water) in your farm and surroundings during your life?
b. What could be the main driving factors you have perceived leading to these changes?
c. What are positive effects in product or service of given resource resulting from changes in their condition? What are negative effects?
d. What are problems that you have perceived for your life and community due to change in given product or service? What are benefits?

3.2. Some limitations

The qualitative method-based study has some limitations. Precise objective measurement of changes of ever-changing resources is a complicated and time-consuming task. Therefore, the changes are expressed in subjective terms (e.g. increased or decreased) and trends. Farmers mostly answered survey questions based on their experiences and conventional wisdom. An effort was made to avoid ambiguous questions. If the researcher felt that the farmers responded based on some their conventional wisdom, then the arguments were verified against some scientific method based studies. Stating benefits was easy for them in many ecosystems services under study but more difficult in others such as climate regulation service of tree vegetation. In such cases, these cases were identified in group discussion and avoided in personal interview. The findings of experimental studies are also used to verify the data collected using qualitative social method.

3.3. Analysis model and environmental criteria

This study followed the Driver-State-Impact-Response (DSIR) framework that has been recently used to analyse benefit or impact of changes in conditions of natural resources and their ecosystems services to people (Haines-Young and Potschin, 2010; Ness et al., 2007). The model incorporates impact effect on the Pressure-State-Response framework that has been widely used to explain environmental resources degradation problems (Patrício et al., 2016; Kelble et al., 2013; Ness et al., 2007).

In a mountain farming landscapes context, many factors determine conditions of natural resources and their ESs. Fig. 3.1 is a DSIR framework containing five main elements: Pressure (driver), state, impact, beneficiary including stakeholder, and response. It depicts that one element of the framework affects others and some elements result in feedback.

The drivers or pressures can be economic changes associated living means and income; population growth and migration; technology and infrastructural development; political and other institutional changes; external interventions; and global environmental change. They can be changes in values or demands for resources and products; availability of labour and skills; access to efficient means or alternatives; opportunities, regulations and disincentives to exploit or use alternative resources; availability of and access to some resources; and behaviour to adapt against the external risks or disincentives. The pressures of external drivers or stay put forces can result in the resources taking various states: resilient, improving, vulnerable, degrading, verge of loss and extinction. Effects of the changing factors vary between resources. The availability of ESs also changes in response to the changing state of their resource bases. The changes impact on the environmental, economic, social and emotional (e.g. altruistic) effects on the people. Victims (beneficiaries) and other stakeholders are assumed to respond to the ESs changes. The responding actors can be victims or other stakeholders: private sector (individual and business), enterprises, communities and other civil societies, governments and international agencies. Responses may include avoiding degradation or loss; reducing degradation or loss; offsetting loss; adapting or coping in the scarcity of the ESs; or no action, leading to suffering.

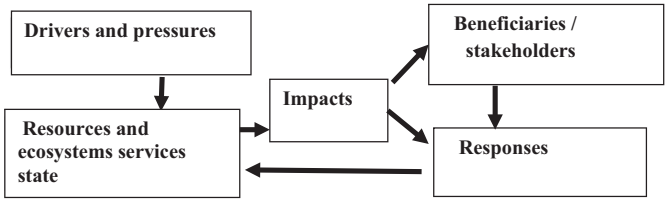

Fig. 3.1. [Driver-state-impact-response model] will be here.

This study focuses only on the resource bases of ecosystems services with high significance from a local community prospective, though agricultural landscapes can host many kinds of resource bases of ESs (Crouzat et al., 2015; Kelble et al., 2013; Perrings et al., 2011; MEA, 2005; Piorr, 2003; OECD, 2001). Instead of broad ecosystems service categories (supportive services, provisioning services, regulative services and cultural services) we selected the ESs criteria and indicators that farmers could easily understood. The evaluated ESs are as follows:

a. Atmospheric environment regulation services: climate regulation, ameliorating amenities, and moderating hazards.
b. Biodiversity conservation services: species diversity, genetic diversity and habitat.
c. Soil services: Soil and nutrient conservation, soil quality maintenance and soil formation.
d. Water services: Recharge, supply and water quality maintenance.
e. Waste management services: detoxification and decomposition, sedimentation and storage.
f. Social services: Indigenous knowledge systems, education, cultural and spiritual practices, amenities and recreation.

4. Results

4.1. Atmospheric environment

4.1.1. Regulating climate change

In response to questioning on the causes of changes in fertilization application in their fields, many participants replied that frequent changes in government subsidies, price and availability in market made it difficult for them to say whether their application rate had changed. However, most farmers agreed that the application rate had increased substantially over their farming life due to increasing adoption of exotic crop varieties and decreasing production of farm yard manure associated with policy interventions on livestock. The application increased as they changed their practice of applying only to selected crops and fields in the past to all kinds of crops and fields at present. The farmers also said that there had been minimal change in intermittent irrigation practices in lowland rice fields, which implied little change in GHG emission (anaerobic phenomena). Biogas plants for producing methane gas for household cooking were observed in the yards of most moderate and high-income households in the lower altitude belt. This practice resulted in better decomposition of farm yard manure for field use as well as reduced GHG from firewood use. The farmers reported that livestock holding size had decreased substantially over the course of their lives. However, the reduction resulted in the small farmers having to mix human and livestock excreta for producing more biogas. Declining livestock numbers of small holders also resulted

in increasing of GHG emissions in intensive commercial livestock farming (large size and grain-feed based farming). In general, changes of farm activities associated with influences of external factors had resulted in lower GHG emission and may have contributed to regulating climate change.

Fig. 4.1 shows tree status in a farm landscape in two different years (2003 and 2019). This is illustrative of a general trend toward increased arable land abandonment from farming, and tree coverage in agricultural landscapes. Farmers said the changes resulted mainly through external support and advice, and changes in livestock farming practices. Some farmers shared experiences of fewer fire incidents in their forests over three decades. The change was the result of increasing community involvement in management and decreasing people's dependency on the forest resources. The practice of burning of farm residues was decreased with declining farming activities in marginal lands. Increasing availability of biogas and electricity reduced the demand for firewood for household cooking and heating. Some farmers said the reduction of firewood use was caused by many factors such as changes in lifestyle, declining livestock holding (feed preparation), the quality of housing construction, and access to warm clothes. In group discussions, many farmers reported an increasing trend of abandoning arable land previously used for intensive cultivation. Intensity of tree vegetation increased in the abandoned lands. The farmers stated that the problem was a reflection of increasing labour shortages within farming families and across communities as young people migrated for overseas jobs. The changes in tree numbers, forest fire and firewood practices associated with external forces may have contributed to mitigating GHG and reduced climatic variabilities. However, farmers had little confidence to answer whether their communities may have benefited from the emerging practices contributing to climate change.

4.1.2. Ameliorating amenities

When elderly respondents were asked to describe differences in local air quality between when they were young to the present day, they reported that some differences had occurred, mainly due to changes on in-house smoking, land surface coverage, and sky visibility. According to farmers, on-farm smoke levels had decreased due to reductions in domestic firewood use, agricultural residue burning, slash and burn farming and forest fires. These activities decreased due to changes in land use practices, labour shortages and availability of alternative means. Even though number of households using firewood increased with an increasing human population, it is an in-house activity which releases out only a small proportion of unburnt carbon particles. Some respondents said that increasing the cropping intensity reduced the exposure period of plowed soil and consequently a reduced level of dust in the sky. They also said that improvements in housing construction quality, and shifting to biogas and electricity energy, reduced in-house pollution. They had noticed a reduction in health problems. However, foothill belt residents shared their experiences of increasing hours and days of foggy weather during winter. An increased occurrence of potato blight was a noticeable farming effect of the foggy weather. They also reported an increasing number of hazy sky days during off-rainfall seasons. The people believed motor vehicle related activities resulted in the hazy sky and sad feeling weather but growth in polluting industries and residential crowding downstream might have caused the problem. The development of fair-weather motorable roads had substantially increased soil dust in the dry season.

4.1.3. Moderating natural hazards

Farmers were asked to relate their experiences of changes in natural disasters in their lifetime and potential contributing factors related to farming. In response to the question of whether local deforestation and other farm activities increased atmosphere-related natural hazards, most of them hesitated to agree that local deforestation had changed local environmental phenomena, resulting in large-scale weather disasters and droughts. Some elderly people shared their experiences of widespread disasters in the 1970s associated with the high intensity of rain, landslides and flood events which dramatically changed the stream courses and natural landscapes for many areas. They had observed a few such high-intensity events, but the events were not of as wide a scale as those of the 1970s. A respondent pointed to a dense forest on a slipped land mass and contradicted the argument of the deforestation-based natural disaster. Some elderly respondents said that they had not experienced prolonged drought to the extent that had made their family give up planting of crops at the early age of life. They also reported that big trees in the ridges of hills that once had the potential to change direction of wind and intensity of hail had been replaced by young trees, but they had not suffered the intensity of hailstorm damage that they had experienced in their early life.

The farmers reported that fire is one of the most common natural hazards that had changed noticeably over time. In the old days, most houses had thatched roofs so producing sufficient quantities of long grasses was critically important to repairing houses. The farmers would set fires in forest and marginal private lands to get succulent and long flushes of grasses for livestock and roof making. They often used fire to clear bushes from marginal farm lands to maximise the land areas available for food production. Mismanagement of these fires resulted in spreading from the source to unintended sites via the wind, and frequently caused huge human and economic losses. According to the farmers, declining livestock holdings and grazing practices also reduced their farm waste burning practices. Increasing income and food from other sources reduced the need for the burning and clearing bushes for maximizing land space. Availability and affordability of

Fig. 4.1. A comparison of land use status in 2003 and 2019.

metal-based roofing materials eliminated the need for grasses for repairing house roofs.

People shared experiences that locally originating dust storms, especially during spring, decreased with increasing the cropping intensity and trees. The crops covered the soil surface and reduced the opportunity for storms to pick up soil. The change reduced the haziness in the sky to some degree and decreased the amount of dust and mud landing on drinking water, community amenities and vegetable crops. However, increasing dust produced by traffic on unsealed roads made it difficult to obtain positive outcomes. Soil particles from exposed land surfaces carried by a big storm in Northern India in the first week of June 2018 came to Nepal's hilly areas (about 1000 km away) by an orographic lifting process that resulted in muddy rainfall by condensation processes after a week. However, local land use changes cannot make much of an impact on the problem caused by large scale atmospheric phenomena.

The farmers also reported a decrease in airborne animal diseases. Four decades ago, airborne diseases such as anthrax killed substantial numbers of animals. Elderly farmers said the incidence of these diseases today has greatly decreased. Even when it occurs, they see fewer casualties than they saw three decades ago. The change resulted from decreasing the practice of animal grazing in open lands and allowing them to drink water from public sources.

4.2. Biodiversity

4.2.1. Plant species diversity

In field visits, many farmers said that there had been substantial changes of species in their community over time. Some elderly respondents said that farming of some crop species became a history for their communities. In response to our request to list local food crop species that disappeared from their communities, they listed fox millet, sorghum, amaranths and barnyard millet (Sama) species. According to their reports, the lost species were conventional crops about four decades ago but have now disappeared from their communities. One of the farmers reported that she searched for fox millet for medicinal use, but it could not be found, even in distant communities. Many respondents listed new plant species currently being grown in their communities. They listed vegetables: capsicum, broccoli and courgettes; fruit: strawberry, avocados, and kiwifruit; and herbs: lemongrass. A few farmers said that wheat was introduced in middle and foothill communities when they were young (in the 1960s). They expressed gratitude for the availability and diversity of these vegetables and fruits. Most of the new vegetable species grow well in the dry seasons or off-seasons of local crops and so contribute to household food security and nutrition enrichment. Some farmers also listed new forage species being grown, including ryegrass, lucerne, napier, stylo, thulo-dubo, and clover. Some of these new species give higher forage yields and the others result in more milk production. The farmers also mentioned that with the new crops, some nasty weed species had been introduced. The weed species were Nilo-gandhe (ageratum), banmara (lantana), kanike jhar (parthenium), and rakte jhar (phalaris-minor). Banmara was found everywhere, displacing the local herb species of titepati and gaitihare. Nilo-gandhe and kanike jhar became established in a maize field and suppressed the emergence of local grass species which were palatable and nutritious to livestock. The economic and biotic impacts of the invasive species might be much pervasive; however, accounting for this was beyond the scope of this study.

The farmers gave diverse reasons for the disappearance of species. The crop species were socially less preferred food source, more labour intensive and less productive than major crops today. According to the respondents, in the past they had grown those lost species on marginal lands to secure family food supplies for their own farms. Evolving opportunities and problems drove the farmers to retire the marginal land from farming and resulted in the loss of the crop species from the community. Many respondents said proximity of motorable roads and growing off-farm income increased their access to imported lowland rice (socially most preferred food crop) and gave motivation for abandoning the farming of these species. Some farmers added family labour, shortage of farm manure, and the high input costs as key drivers for abandoning the farming of the species. Finger-millet had also similar characteristics but special properties for domestic beer and wine production prevented it disappearing from the communities.

The farmers reported mixed effects of the indigenous crop species loss. Some older female respondents said that abandoning the farming of the labour-intensive crop species reduced fatigue and the burden of farm work for women. An older respondent added that people turned to easier lives, but the loss of the crop species reduced dietary diversity and nutrition for farming people. Some expressed a worry about the increasing number of households consuming market-based foods with chemical application and poor nutritional quality. The poor nutritional value of the market food may have worse impacts on people and particularly on women and children, due to their specific health and development needs. One elderly participant mentioned that her grandchildren might grow the disappeared crop species once they realized the health and social values of the crops. Another woman responded that her daughter-in-law could not obtain fox millet seed that she wanted for its known benefits for relieving gastritis problem. She questioned how the next generation could get seeds of the crops.

4.2.2. Plant genetic diversity

Some farmers said their families used to grow many varieties of a crop in a season. They cited the lowland rice case when their parents grew over seven varieties in a season, but they were only growing a couple of exotic varieties at present. Most of the landraces had disappeared from these communities. The biggest decline of landraces was found in rice, maize and wheat crop species in cereal groups and most of species in vegetable groups. Farmers said many new varieties of cereal crops, vegetable and fruits were grown in the communities. One elderly farmer said that not all new varieties were exotic ones. He cited an aromatic variety (Jethobudo) of rice, a native in other districts, which had not been grown in his community for three decades. One woman said that the local and exotic varieties of vegetable species were mixed up in such a way she could not tell the difference between them.

The farmers reported many factors contributing to decreasing genetic diversity, with the introduction of high yielding varieties being primary drivers. Adaptability of exotic varieties to multiple sites was another factor. The farmers said a single exotic variety could be grown successfully and produce a yield better than the local one in a wide range of agro-ecological conditions including marginal lands. According to the farmers, decreasing landholding size and increasing cropping intensification were other factors giving rise to using fewer varieties. Some respondents said that reduction in the farming of moisture stress-tolerant varieties and the loss of genetic diversity at the community level was also caused by abandoning marginal land from farming. This is associated with a labour shortage and the growing cost of farming. A growing shortage of farm yard manure and increasing dependency on chemical fertilizer contributed to the disappearance of local varieties, especially of vegetables and legume crops. The local varieties were chemical fertilizer intolerant and could not be sustained in the fertilizer regime. However, local varieties were found to be extinct, mostly in communities accessible from motorable roads and local development centres.

A few old farmers said breaking down the traditional seed maintenance system resulted in the loss of the local varieties. According to them, farmers used to grow only some varieties in a season, but other famers had grown the other varieties. They used to change to the varieties that neighbours had when they experienced problems with the existing ones. The opportunity for this had now gone. One farmer said that he hunted for seeds of some native varieties to plant when he was frustrated by the pest problems in modern seed types, but he was unable to locate any. He said that the development agencies had little

concern about his problem with local varieties. A few development agencies had argued for in-situ conservation. Their arguments are mostly limited to environment conservation purposes and not for providing seeds to farmers when they need them. Even if some farmers and gene bank hold seeds of local varieties there was high risk of genetic drift and quality deterioration. The evidence indicated that external factors have hampered the farming system's ability to maintain indigenous genetic diversity.

The farmers pointed out various effects of the plant diversity changes on mountain farming. Practising new varieties compelled farmers to buy fresh seeds from business agencies on a regular basis. Otherwise crop yields decreased sharply due to rapid deterioration of seed quality of the introduced varieties. In case of hybrid varieties, they needed to buy new seed every growing season. Some farmers said they had to overcome many hurdles to get good quality of seeds from market agencies. The seeds often resulted in complete failure of a crop that would not happen in case of local varieties. A few other farmers said that they rarely planted the hybrid varieties of rice due to the high price of seed and fertilizer and the difficulty in getting seeds. These facts indicate that recent technical changes have hampered genetic diversity and subsequently seed autonomy-based food security for the mountain community.

The farmers also shared evidence of the unsuitability of modern varieties in conditions of extreme climatic variability. The farmers with modern rice varieties could not grow the crops in the rain-fed land in 2017 due to low rainfall (i.e., not enough to puddle the soil for seedling transplanting and survival) during the critical seedling transplanting season (late July). Their seedlings became older than a month and produced internodes before getting adequate rainfall. If they were transplanted after the rainfall, the harvest would not cover the cost of production. The farmers said that the seedlings of indigenous varieties would not produce internodes that early. Some farmers also shared their experiences of high frequency of stem borer outbreak in modern varieties of maize crops. It was difficult to conclude whether climatic variability or the physiology of the maize varieties favour the pest. Even if farmers get good quality seeds of the modern varieties they contain highly homogenous genes which results in a higher risk of large-scale production failure by biotic and abiotic stresses (drought, hail and wind). Local varieties were passed through numerous episodes of climatic and other environmental stresses and could produce some yield in any disaster event.

The farmers also shared postharvest problems with modern varieties. Based on their experience, the food taste of some varieties declines noticeably six months after harvest, meaning that the grains of some modern varieties must be eaten before the spring season. The taste of foods from most indigenous varieties would be hardly different even after a year of harvesting. The new varieties were also found to be more vulnerable to pests, especially moths and weevils in store. The postharvest problems urged the farmers to use modern storage containers and advance of techniques which can be costlier.

Some farmers reported that some exotic varieties had brought diseases and destroyed local varieties. The problem was most evident in the case of cucumber and citrus species. A local variety of cucumber, for example, was easier to grow, four-five times bigger in size, more prolific in production and had a longer growing season than the newer exotic ones. The farmers said in the last rainy season the crops vanished from many communities as development agencies introduced modern varieties for early harvest. One of the farmers said that his desire to eat cucumber pickle in Dashain festival at present was limited to his dreams and memories. Similarly, plants of a local variety of giant lemon (locally known “Nibuwa”) can be hardly seen in local communities. The problem resulted in lemon paste shortages for customary meal making. Potential economic, health and cultural impacts of the loss of the local varieties are likely to be pervasive. The effect of loss of the varieties might be higher on farming women who have traditionally practised their products to alleviate their special health problems.

A few farmers said fruit and vegetable products of most modern varieties ripen almost all within a week and last only a few days. The varieties are not suitable to grow in home gardens and use for home consumption. Indigenous varieties had intermittent flowering and fruiting nature which was convenient for people to get a fresh harvest from their kitchen garden over many days in a season.

Some farmers stated that modern varieties resulted in some problems for livestock farming. Straw of most crop species is a primary feed of livestock, especially in dry season when other sources of feeds runout. Most modern varieties produce less straw than indigenous ones and created a shortage in animal feed. Farmers said that they could readily get food for humans in the local market, but not animal feed. The prices of grain feeds available in areas accessible by motor vehicles were also too expensive. Reduction of the feed supply potentially contributed to an increasing slaughter of young buffalo; however this issue requires further study.

However, most famers stated that adoption of modern varieties had made a big difference in their lives. In response to the question asked about most promising benefits of the varieties, the farmers replied these new varieties had increased their farm production by over 40% in general, and almost double in some cases. The varieties substantially reduced their food dependency on markets. The new varieties ripen a month earlier than local ones and this has made it easier for farmers in land preparation and planting subsequent crops. The farmers had added some new varieties of vegetables that grow well in off-seasons too and this contributed to improving dietary quality and meal tastes. Considering the benefits, a few farmers expressed gratitude for the modern varieties and expressed little regret for the loss of indigenous varieties.

4.2.3. Livestock species and genetic diversity

In response to a question of whether any livestock species had disappeared from the community, respondents of many communities pointed to sheep. The respondents from lower and mid altitude belts said that the cow had followed the disappearing path of sheep, horse and donkey. The main driver for the disappearance of these animal species was the decline of grazing practices in community lands. The emerging practice of stall feeding was neither suited to animal behaviour nor profitable for management. However, new livestock species such as Angora rabbit and turkey found in other parts in the country were not observed in farmers' fields.

In response to the question of negative effects of the disappearance of sheep farming, many respondents replied that it hampered the opportunity for getting sheep meat and wool locally. The respondents from the Ghale ethnic group replied they were supposed to eat only sheep meat for cultural reasons but increasing scarcity of sheep made it difficult for them to practice their culture. Elderly people from Hindu communities said that the declining population of cows made it difficult for them to follow their spiritual and religious practices.

The farmers told that exotic breeds of other species have not been proliferating. Observable changes were found only in buffalo, goats and poultry species, primarily in the communities with easy access to roads and animal healthcare services. Hundreds of milking buffaloes were imported from Terrai each year with little protection of offspring. The farmers said they could not get loans from banks and other modern development services (e.g. insurance) unless they bought exotic breeds from those places. Some farmers said that they would like to graze their livestock in farmland and public places in the offseason as an extra resource and for conserving feed, but the exotic breeds could not walk well on sloping land. Oxen of the exotic breed cannot fit for farm ploughing in narrow terrain of mountain but local breed do (Fig. 4.2). These were the barriers because the farmers poorly adopted exotic breeds from the plain areas and hotter climatic condition). According to the farmers, exotic breeds remained productive and reproducing for only for a few years, due to difficulty in adapting to the cold climate or to poor management. They were required to sell the unproductive

Fig. 4.2. Uses of local breed of oxen for ploughing field in mountain.

animals for slaughtering after only a few cycles of production. Many farmers said labour shortages and feed cost compelled them to sell their calves mostly for meat consumption, and this hampered buffalo breed improvement. Cow breed improvement was limited, even in the communities with motorized transportation facilities. Some farmers said that legal and religious restrictions on selling calves and unproductive cows to slaughter discouraged them from keeping costly exotic cattle breeds. Most poor farmers and women still preferred local breeds over exotic breeds, as they give substantial amounts of milk on poor feed and have low healthcare needs. Some farmers said they would not like to adopt grain feed intensive livestock farming to minimise the risk of food grain shortages for humans. Development agencies, however, had little concern for the indirect benefits of indigenous breeds and the circumstances of poor farmers, and they purposely introduced exotic breeds to meet their interests (show progress quickly) and values (exotic are better).

Many farmers reported that extensive adoption of the exotic breeds was constrained by the need for intensive modern animal health care and nutrient-rich feeds. Adoption of exotic breeds was rare in remote areas where access to development services and markets and delivery of exotic breeds was diffcult. In the high mountain areas, transhumance and forest grazing systems of livestock had played important roles in genetic transfer between communities and the improvement of animals in the past. According to the local farmers, the introduction, and expansion of wildlife conservation and community forestry development policies and practices also restricted the grazing system and reduced the herd sizes. They also hampered opportunities for animal movement between communities. The indirect impacts that these changes might have had on the animals' genetic improvement and genetic drift are the subjects of current laboratory studies.

Many farmers stated that they had reduced their livestock holding. Many factors contributed to reduce the holding. The farmers said that family labour shortages and decreasing private land holding size were key factors. Another important factor was restricting the traditional practice of livestock grazing in, or fodder collection from, public or community forests. Many farmers said that in the past they sustained their livestock business by supplementing the animal feed from forest resources in old days. The fodder products and grazing opportunity of forests were especially important during times of food scarcity and at the height of the cropping season in private lands. Government policies and development support agencies now restricted the forest uses for global climate change mitigation and wildlife conservation. Ordinary farmers were powerless to resist the strategic intervention of the powerful external agencies. Some elderly farmers said that the attitude of youth regarding working on the farm and the tendency of migrating overseas for work affected the ability to keep livestock and therefore the breed dynamics. Household cooperation within communities for keeping animals and grazing in forests was also found to be decreasing, with declining numbers of households keeping herds. Government incentives and support schemes were inadequate to keep the labour force in the country and involved in the livestock sector, particularly in indigenous breed-based farming.

In response to the question about promising aspects of introduced breeds, many farmers replied that milk production had increased substantially in the case of buffaloes, but only marginally in cows. Meat production had increased in case of pigs, poultry, and goats. The adoption of improved animal husbandry practices had led to noticeable increases in income and employment. According to the farmers, the consumption of animal products, especially meat, has substantially increased over three decades. However, uptake of exotic breeds was limited mostly to the farmers who were living close to motorable roads and markets and managing animals for commercial purposes with the intensive farming systems. External factors had a net negative effect in local livestock production which has affected local income and employment, and community vitality, particularly in disadvantaged localities. It has contributed to a shortage of bullocks and farm yard manure.

4.2.4. Habitat

Despite their effect on local crop species and varieties, external forces have contributed to increasing tree and crop intensification which has provided corridors and habitat for some wildlife. Local farmers reported that the population of birds and leopards had increased in and around the farm and forest edges. Many farmers said drinking and irrigating water facilities substantially increased soil moisture or stagnant water in residential areas and kitchen gardens, which increased mosquito, bee, wasp and moth populations. Bees and other flying insects were observed more frequently while walking in an upper part of hills during the field visits.

Many farmers, however, said that they had not seen the same number of frog populations on their farms, compared to several decades ago. One farmer said that the “twar-twar” (croaking) sound of Paha and Bhaguta (frog species popular in the old days) had decreased substantially. The farmers pointed to chemical input application in farm as a contributing factor to the species declining. They also shared experiences of sharply declining populations of dung beetles compared with three decades ago. The species used to live in the fresh dung dropped by the livestock and was applied in crop fields. The beetle's access to the dung decreased once the traditional pattern of open grazing and migratory farming systems for livestock were restricted in communities. Some farmers reported noticeable declining populations of woodpeckers and owls which used to live in old trees of fodder, and other species in croplands and surrounding forests. The resources declined as people harvested the old trees for construction purposes during timber supply shortages from public and community forests. The farmers also mentioned that Karyng-kurung (Siberian Crane), a long-range migratory bird, rarely landed to rest for the night on their migratory path nowadays. The farmers believed that intensification of farming, especially during spring, reduced the open areas required for the birds to land and they had now diverted to other routes. The diversion of water from farming land may have other negative effects on aquatic habitat in natural courses, a factor which is beyond the scope of this study. The farmers, however, could not identify direct benefits and harms of the ecosystems change.

The vegetation intensification and wildlife dynamics resulted in some negative impacts on farming in marginal lands and lands remote from residential areas. Some farmers said that they abandoned crop farming and grazing livestock in the lands due to increasing crop and livestock loss by wild animals. Some old women said increasing wildlife populations, and decreasing farming activities and the human population made the farm lands scary places to work and reinforced the abandoning the land from farming. The changes might have contributed directly and indirectly to loss of micro-ecosystems, indigenous breeds, and landraces. However, bee farming was found to be proliferating, due to increasing foraging resources associated with vegetation intensification and water availability in farms.

4.2.5. Changes in superior gene selection and evolution systems

The mountain farmers had a tradition of selecting and using seeds of superior lines. The centuries-long selection and growing practices resulted in the varieties genetically stable and made adaptable to various biotic and abiotic stress conditions. Some of the varieties had been endemic in specific topographic regions. Farmers used to get better quality seeds from other farmers when the quality of seeds from their farms had deteriorated. The practices had alleviated development of genetic shift (genetic and phenotypic qualities deterioration associated with growth in new agro-climatic areas) problems of introduced species or varieties.

In the field survey, farmers reported that the traditional seed selection practices disappeared with the declining of indigenous varieties. Declining number of growers of indigenous varieties also reduced the chances of maintaining the gene diversity. It increased the risk of genetic drift even if some varieties grew in a few localities or were stored in gene banks. A few development agencies often argued in-situ conservation. The arguments were mostly limited to conservation purposes rather than for providing seeds to farmers when they experienced what we found in the field. One farmer reported that he hunted seeds of some native varieties to plant when he was frustrated by the pest problem in modern types, but he could not get them. The development agencies had little cared about his problem.

The negative impact of the changes in the seed supply system was disproportionately high on poor farmers. Most poor farmers could hardly select and plant superior seeds from their farms due to insufficient production for food, and seed storage problem. They could get the seed from the wealthy farmers who could manage quality seeds. In the field, most of the large landholders particularly in the accessible areas had adopted hybrid varieties whereas many poor farmers practised older generation seeds of modern varieties. The change in seed production systems had reduced the opportunity of improving and exchanging seeds of the landraces and supplying to less wealthy farmers, especially in the communities disadvantaged from development facilities. Introduction of exotic varieties of cross-pollinated crops might have potentially hampered seed quality of local varieties (Kadam, 1942), which could not be studied well.

As stated earlier, the farmers experienced the problem of rapidly declining seed quality of exotic varieties. The farmers had to buy fresh nuclear seed of conventionally improved varieties from the market frequently and every production season in case of hybrid varieties. Seed agencies (crop breeding and business agencies) generally supply the new type of varieties in each or within a few seasons. The practice of frequently changing varieties and their seeds not only increased seed insecurity but also hampered the social environment of developing or evolving genetically stable and locally superior varieties in the mountain agro-ecological region through the socioecological process.

Traditionally farmers used to select better progenies of animals for reproduction and contributed to crop and livestock improvement. The system was found still intact in remote communities. Even if only a few farmers had used sires of exotic breeds they contributed to genetic improvement particularly of buffalo, sheep, and goat. Breed improvement in case of cattle was found to be barely practised and with little success even in transportation facility areas. In case of buffalo, many farmers in road accessible communities were used to buying milking adults imported from Terai and India. The farmers reported that exotic breeds remain productive and reproducing only for a few years due to adaptation problem in cold climate and poor management. They were forced to sell unproductive animals for slaughtering after a few cycles of production. Interestingly, many farmers reported that they sold their young buffalo.

4.3. Soil services

4.3.1. Soil erosion control and land stability

In field observations, most of the lands looked reasonably level. But at close inspection passive soil erosion and landslides problems were found in varying degrees, depending on land use and topographical conditions. Lowland rice growing fields were well leveled to retain water for puddling and irrigating so surface soil loss was negligible. Substantial degrees of surface soil loss by wind and runoff was observed, particularly from upland areas during the summer season. Slashing and burning farming was not practised in these communities.

In response to a question about serious soil losses events, many farmers replied that a heart-breaking soil loss occurred only in the heavy rainfall events immediately after soil preparation and maize crop planting. A few farmers said that they experienced worse soil loss from marginal lands but most of these lands were abandoned. According to the farmers, rural road construction work resulted in huge loss of soil in their localities. Some farmers said that massive landslides, mass movement and serious soil loss occurred, even in leveled lands in intense rainfall years. Some of them shared experiences that unpredicted extreme rainfall and landslides had occurred in some specific areas over a few decades. The events had resulted in some remarkable land use changes upstream and historical river course changes downstream. According to their reports, the practices of immediately repairing lands destroyed by floods and landslides decreased due to family labour shortages and high cost of hired labour in the community. The failure to repair fields such as rice paddocks had resulted in devastating destruction of some lands, especially those with shallow soil in the lower part of the catchments. Some farmers said that the farmers who got galvanized wire from government and other development agencies, built soil stabilizing structures in the fields with frequent landslides and soil loss problems. However, the built structures were not in common practice in areas with persistent mass movement of land. The terrace areas deformed and damaged by the mass movement forces were also abandoned from farming.

Moderate degrees of landslides and field sedimentation were induced by recent activities of community road development. The problem was observed to be widespread in the mountain agricultural landscapes. Some farmers said the problems were caused by poor technical advice from engineers and the influence of political leaders on the road construction. Most community roads were not sealed. As a result, the soil dust of fair-weather roads raised by vehicle movements could be seen from a considerable distance during dry seasons. Crops and other amenities adjacent to the road were also covered by the dust. The remaining soil was washed away by runoff of rainfall events and deposited in downstream crop fields and stream sides. The landslides and sedimentation had substantially hampered field work and crop production.

However, some farmers said some recent changes in farming practices had reduced soil loss. According to them, new crop varieties and modern vegetable farming practices enabled crop intensification which contributed to reducing soil work activities and the exposure period of soil to erosion agents. The farmers also said increasing access to high yielding rice varieties and irrigation facilities motivated some farmers to leveling up and maintaining terraces in the rainfed sloping lands. Increasing social preference for rice meals over other foods also encouraged the expansion of rice farming areas and leveling up the terraces. In many communities, substantial farming areas, especially marginal lands were found abandoned from arable cropping and used under less erosion-prone cropping activities. Some farmers stated that decreasing livestock grazing also resulted in less soil loss in both agricultural fields and community pasturelands.

4.3.2. Soil quality

In response to the question about farm soil quality changes over the last three decades, farmers reported a dramatic change across their working landscapes. In past, residences were mostly in uplands dominated by maize-millet farming on upper hillsides which were away from major rice farming land in the foothills. Farmers applied a major proportion of their farmyard manure in the fields close to their residences. This practice resulted in better soil quality in the uplands

despite regular losses of soil nutrients by runoff. Today many farmers have migrated to foothills with modern development facilities and services and apply most of their farmyard manure in rice fields. Farming in the upland areas, if any of the migrants are still farming, is mostly based on application of chemical fertilizer. The farmers shared their experiences that the change in soil fertilization practice reduced not only soil quality and crop production but also resulted in a drier soil and tilling work was harder in the upland. The use of chemical fertilizer might have increased soil acidity (pH) level which changes microbial activities and soil structures. Some farmers said that the changes in soil fertilization practices resulted in observable differences in the composition of the vegetation in the walls of the terraces, and occasionally in the field margins. They added that the productivity of foothill lands increased significantly with the increasing application of farmyard manure. The lands previously classified as marginal quality in the foothills are now regarded as productive. Some farmers acknowledged that decreases in land holding size and labour shortage for manure transport to uplands has contributed to increasing the amount of manure applied in low land areas. A few of them said that the diminishing quality of upland and other marginal lands was due, at least in part, to a decline in livestock holding and restrictions on mobile herd grazing in forest areas. Their negative effects on restoring essential nutrients and organic materials in crop fields were found to be much greater in the lands distant from residential areas and in remote regions.

Modern production inputs also influence soil quality. Many farmers said that they increased application of chemical fertilizer to get maximum potential return, particularly of exotic crop varieties. But they mostly applied nitrogen fertilizer and occasionally phosphorus and potash. Almost all farmers had never applied lime to adjust soil pH. Only a few farmers, who got them free from promotional agencies, had applied other micro-nutrients. According to the farmers, traditionally, farmyard manure was only the source of micro-nutrients and organic matter restoration. Its application decreased with declining livestock holdings. Farmers also shared experiences of other side effects of chemical fertilizer usage. Most farmers reported that the application of fertilizer reduced soil quality for growing following crops unless enough farm manure was applied along with fertilizer. Some of them said that fertilizer use also affected the traditional practice of intercropping, particularly of legume and cucurbit species with cereal crops.

Agricultural soil can also be contaminated with toxic chemicals which are mixed through the application of solid wastes for improving soil productivity, and pesticides and hormones for making crops fast-growing and attractive. In response to questioning as to whether they used these resources, a few farmers said they collected organic waste and applied it to crop fields. Some of them said they irrigated their fields by runoff and waste-contaminated water drained from urban areas. The waste and water might deliver increased biological and chemical hazards to the soil. However, the application of chemical and hormones decreased with market distance and increased marginally over the years. Many non-commercial farmers farmers replied that they also applied pesticides to control stem-borers of maize crop. Most modern production inputs may have many other negative effects on soil quality but none of the farmers reported the problems except of the fertilizers.

Some farmers also said decreasing livestock holdings reduced grazing pressure and contributed to increased vegetation cover and soil quality improvement on communal lands. A few farmers said development agencies had helped them to promote vermiculture and green manure cropping practices, but many incompatibilities with farming systems and lack of availability of supporting resources have made these practices ineffective. The trend of perennial cash crop farming in arable land was increasing in some agro-ecological pockets, which might contribute to soil stabilization and fertility improvement.

4.3.3. Soil formation

In a field visit substantial parts of cropping fields were found covered by materials from community road construction and associated landslides. Similar problems were observed in other fields covered by big landslides or destroyed by stream meandering. The lands were not rehabilitated in most communities. The problems potentially affected the food production and income of farmers. The survey farmers said that productive soil rehabilitation in the degraded fields requires activities of leveling land surfaces and building ditches for trapping organic matter and other mineral materials as illustrated in Fig. 3.1. They added that rehabilitation by slowly natural recovery land requires bringing foundation soil and decomposable materials from other sites. The tasks are highly labour-intensive and were traditionally done by males. The increasing shortage of male labour in the agricultural sector shifted the responsibility of the labour-intensive works to the shoulders of women who were traditionally trained mostly for household works and not for rebuilding the degraded or deformed land structures. Therefore, the lands are abandoned for farming or used for non-food crops. The farmers said that ease of access to food from alternative sources and high labour costs also contributed to abandoning the traditional practices of soil formation. Fig. 4.3 good and abandoned practices of farmers for soil sedimentation and soil formation.

However, a few farmers shared their experiences of increasing soil depth in marginal lands close to urban area and foothills. This is where cropping intensification increased with greater application of tillage and fertilizer. They had also considered that there had been an increase in soil depth in the land which had been recently irrigated. Irrigation motivated farmers to level farming land which facilitated plant material decomposition and contributed to settling down of organic materials and soil formation. Based on our knowledge of recent literature, other studies have not assessed the effects of external factors on soil formation in the mountain farming context.

4.4. Water services

4.4.1. Water recharging, conservation, and flood reduction

In response to the question about what emerging trend of soil water recharge change was, some farmers replied that crop intensification increased tillage activities and the duration of plant presence in the field, which might intercept water flow and contribute to flooding reduction and water recharge. However, increased crop intensification was found mostly in foothill areas where economic infrastructures were better developed. Cereal cropping (e.g. main, rice, and millet) and field restoration practices enhancing water recharging, conservation, and flood reduction services were found less often in upper parts. The changes may have more affected downstream communities who are the principle beneficiaries of enhanced water services from the farming practices in upper belts.

Perennial vegetation coverage was found to be increasing in both public and community lands. Forest conservation policy and development support have promoted tree intensification in the farms and community lands for climate change mitigation and biodiversity conservation.

However, small-scale water conservation and storage was found increasing due to the use of concrete based storage ponds and tanks, and plastic containers. The water loss also decreased with the use of pipe and concreted irrigation canals from water sources. However, the infrastructural practices increased availability of soil water recharge in agriculture-based catchments and reduced water availability for recharge in other areas.

4.4.2. Water supply

In response to a question regarding recent changes in water availability and usage, farmers replied that there had been substantial changes in water use practices. In earlier days, they would irrigate winter and summer crops (wheat, potato, onion, and maize) by stream-based canal water. Now the streams become almost dry in winter and summer seasons as their sources of water (springs) were often diverted by pipe for household use. The change in stream water flow necessitated changes in cropping types in some fields and increased cropping

Figure 4.3. Good and abandoned practices of farmers for soil sedimentation and soil formation.

intensification. Increasing the cropping intensification increased soil activities which contribute to water storage more than the soil water losses by evapotranspiration processes from the crops. The households, however, utilized the water to grow vegetables in their residential plots all-year round. The increase in availability of water in rural areas has resulted in an increased production of vegetables, reduced workloads and improved nutrient availability to the rural people and particularly to women. The farmers also stated that there was a substantial increase in vegetation in the stream catchments. However, the vegetation intensification, may have increased loss of soil water by evapotranspiration from the plant and affected dry season stream flows. River water originating from glaciers found little use for irrigation due to siltation, low temperature and lifting cost.

Most people said that over three decades their communities shifted from getting water from nature reservoirs to using pipe supplied systems. Generally, smaller communities had got pipe water directly from springs in farming and forest areas whereas towns or large rural communities got pipe water from the streams with collection and filtration. River water from glaciers has not been commonly used for drinking except in the foothill belt where water is very scarce. Traditional systems (e.g. tapping from the roof or similar minor structures and storing in ponds) for rainwater harvesting for household purposes and farming were rarely found in practice. The people said the new water supply systems resulted in a huge change in their lifestyle. Interestingly, large engineering structures to store irrigation water for long periods have hardly developed in the area.

Biotic systems were affected by the changes in water supply systems. As the availability of the water has changed it has affected the supply of dry season drinking water for wildlife and aquatic animals. Traditionally their water supply was based on water retained in rice terraces or came from springs. A few people reported that they encountered a wild animal drinking water in their backyards. However, the new water supply system benefitted some bird species inhabiting farming and residential areas. The increasing period of water retention in kitchen garden areas also fostered the breeding of pests, especially insects. People shared experiences that the period of mosquito bites increased when regular water stagnation commenced in backyards and kitchen gardens.

4.4.3. Water quality

In the field survey, local residents shared their experiences that the change in water quality had occurred substantially over a few decades and these have had a mixed effect on human and environment health. One of the positive changes in the water quality was caused by changes in traditional practices of using the agricultural and pasture lands for human toileting, and grazing livestock in the catchment of drinking water sources. Many farmers said that the incidences of human parasites (e.g. roundworm and giardia) and disease transmission in rural communities substantially decreased after introducing a piped-based drinking water supply system. Stationery toileting practices reduced the water contamination with from human and animal excreta. Some farmers reported that turbidity, colour and odour of stream water improved, especially during the summer season, as they restricted livestock grazing on farm and community lands and prevented direct access of animals to the water sources. Increasing farming intensification also reduced soil erosion and contributed to reducing water turbidity in summer and the rainy season.

Some respondents reported some ill effects arising from poor water quality from new farming practices. They told of increasing practices of using pharmaceutical and birth control products and disposing of their leftovers in the soil. The farmers said that the application rate of fertilizer, pesticides, and plant growth hormones was increased but mostly in commercial purpose crops. They used commercially supplied feed from markets to feed the animals kept for producing milk for sale. Some farmers said they got an unpleasant taste of milk products because the commercial feed producers used a substantial amount of chemicals to stimulate the milk production system of the animals. In group discussion, many farmers said that the households with biogas plants disposed of the toilet slurry and solid waste in the field. It might have polluted water. They added that they get runoff and waste contaminated water drained from the urban area which was a source of water pollution. The farmers said eutrophication occurs in stagnant water bodies in the high chemical application areas particularly in the summer season. However, they did not notice or experience any other problems related to chemically-contaminated water.

Some elderly people shared their experiences of increasing water pollution in river systems. In the old days, the cold water originating from glaciers and springs were considered safe for drinking and holy product for a bath. Today, the water drained from intensive farming lands, residential areas and urban sewerage has become unsafe and mixed into the water of the holy river. The water drained from the areas is hazardous for drinking, showering, and irrigation purposes. The farmers said the social value of the river water has been decreased. Many devotees of the river said that they had abandoned the practice of using the river water to shower and flush their mouths. A few people mentioned that they used to wash their body with tap water immediately after showering in the river water.

4.5. Waste assimilation and hazard management services

4.5.1. Decomposition and detoxification

In response to the question about changes in application of urban waste some farmers said that decreasing production of farm manure and rising fertilizer prices have increased demand for waste to apply to fields. However, organic waste production was found to be small in quantity due to small size of towns. Some farmers reported that they

collected waste for making compost and applying to their fields. They said the compost was applied irrespective of crop type, farming practices and environmental sensitivity (e.g. proximity of drinking water sources) of the fields. We observed almost all households mixing human excreta and animal dung to produce biogas. They did it following advice from development agencies. Development agencies had provided subsidies and technical advice (especially under biogas energy development programs) to assist the farmers in applying human excreta for biogas production and using its slurry in the kitchen garden and in other crops. On supplementary questioning the farmers appeared to have little awareness of the potential hazards to human and environmental health of mixing these wastes into the soil. Fortunately, the practices were found less often in the upper belt due to a declining number of residences and slim prospects of urbanization. In response to our question as to whether their land had increased scope for application of decomposable waste, a few respondents replied cropping intensification and diversification practices reduced chances of application of such waste. However, construction of rural road networks in new communities increased accessible areas for the application of waste.

4.5.2. Sedimentation

In field visits, fresh sedimentation materials were found in many fields and streamsides. According to farmers, these materials are produced by landslides and flood loads associated with rural road networks expansion, and some extreme rainfall events upstream (Fig. 4.3). Sedimentation of rocks in streams hampers the volume of water flow and availability, especially during the dry season. Some farmers said that the tradition of leveling fields and building barriers of stones, muds or plant foliage to sediment the flowing materials had declined due to unavailability of family labour for the physical work, the high cost of hired labour, and increasing abandonment of marginal land from farming. Substantial amounts of sedimentation materials get collected in runoff paths, especially in community land and trails during dry season. Some farmers had utilized the materials to fertilize their lands in old days by irrigating the first flush of runoff from the lands. Many farmers said they rarely utilize those materials and thus they contributed to flood reduction at present. Crop intensification and restriction on livestock grazing practices, however, had reduced the volume of sedimentation in farm land run offs. Thus, the influences of external factors both increased demand for sedimentation services of farming land on the one hand and hampered these services on the other.

4.5.3. Indecomposable waste storage

In response to a question about changing practices in the management of debris (an indecomposable waste), many farmers replied that the practice of storing non-useful stones or boulders from landslides below the ploughing depth of soil had decreased and the practice of piling them up in a corner of a field had increased over three decades. This had reduced the land areas available for crop production. They said that the growing cost of hired labour and shortage of family labour made the piling up more profitable than dumping the stones and boulders underground. Industrial recyclable wastes (bottles, cans, plastic boxes, and metal tubes and other plastics-based products) were found to be reasonably well managed or used in the areas accessible to a road. The wastes were observed more often in fields as the distance from market centers and roads increased. The small-scale made collection and recycling too costly in these areas. Some households put the materials under the soil or a terrace wall in the communities. The non-decomposable wastes have less environmental risk. The areas for storing the materials were growing with increasing construction of rural roads. But farmers had rarely utilized the waste service.

4.6. Social services

4.6.1. Indigenous knowledge development

In response to a question asked about factors affecting the indigenous knowledge system the respondents explained with examples. One elderly man said that in the past, people had adequate time and opportunities to interact with their families and communities, and to share knowledge about historical and natural events of the locality and experiences of their lives. He added historical events in their communities were not documented on paper. Instead, their histories were preserved by word of mouth passing from one generation to the next. Young people would like to chat with their elders to hear their stories in old days, but they rarely chat nowadays. Growing emigration and off-farm job opportunities also limited the opportunity for communicating histories and local knowledge from old to new generations. The elderly added that others in the community spent most of their free time watching TV and playing on their smart phones and rarely chat with the elders. A woman also shared how changes in her way of living affected her indigenous knowledge. She had helped her mother-in-law to make home medicine for relieving coughs, back-pain and weather stresses by collecting parts of various herbs, vines and other species from both farmland and forest. However, since the government introduced livestock grazing restrictions, she no longer visited the forest to collect them for making home medicines. She doubted that the plants would even be present any longer because the forest canopy and invasive species might have suppressed them. Her family had also abandoned maintaining medicinal plants growing on her farm as they did not get the forest plants essential to make the complete mixture. As a result, her family shifted to using pharmaceutical medicines. She added that her daughter-in-law rarely heard the names of the medicinal plants and could not recognise them. Another old lady said that medicinal use of some food crops decreased because they ceased farming the varieties that had known medical values. The farmers had grown and used the local varieties for many years and gained the knowledge with repetitive uses in life. They now had to grow different exotic varieties based on availability in the market and could no longer gain such knowledge. These cases indicated that economic and social circumstances as well as policy changes played roles in the declining natural resource-based indigenous knowledge of people in the mountain region.

4.6.2. Educational

In response to a request for farmers to explain the changes in the education uses of their farming resources over a last few decades, many farmers replied that they supported to numerous researchers and students from both Nepal and overseas. They visited and interviewed the farmers about their local practices of natural resource management at farm and community level. Some of the researchers asked for their experiences and opinions about weather pattern changes, adoption of new crop varieties and animal breeds, land use dynamics and food items in their diets. Other scientists visited farms to observe working practices. Development support agencies also experimented their technolgies to check suitability for upgrading their working capacity and services. A few farmers said development agencies, students and farmers visited their community mostly for observing and learning new practices. Most of the farmers said that visiting frequency of the researchers, students and farmers from other districts increased dramatically after the development of motorable road and communication services in their localities. The above evidences indicate that the uses of educational services of natural resources increased mostly for understanding new developments and only a little for traditional practices.

4.6.3. Cultural and spiritual services

Many respondents stated that population growth, communication facilities and cultural awareness increased their values and demands for the goods of resources of cultural significance. The abundance of some products in market and field also indicated that production

practices of many resources with cultural significance were increased. Some people said that a number of minor crops and local varieties common in cultural activities in the old days were now hardly grown in local areas. Some synthetic materials, similar to other materials or imported products available in the market, were increasingly used as substitutes of the local products, but the values of the natural indigenous products found were high. Interestingly, foods of some culturally-significant minor crops were found in restaurants in cities, but rarely in rural areas. In general, the external forces resulted in mixed effects on providing cultural services of agricultural landscapes.

Intimate connections of the lives of mountain communities to the natural environment have contributed to developing and strengthening their beliefs and behaviours. Some of their beliefs and behaviours have acquired spiritual values and have been considered sacred. This is because using the resources in their cultural ways contributes to addressing the beliefs of practising communities and relieving them from psychopathological problems. In response to a question on how the resources of spiritual services had changed, people had mixed responses. Opportunities of visiting distant communities and the availability of seedlings in nurseries increased practices of planting many plant species with spiritual values. However, the number of sacred land sites were found to be decreasing due to abandonment of farming land and migration from old settlements. Many elderly people expressed worry about decreasing practice of keeping a cow that Hindu culture consider to be a sacred animal. The animal products, especially milk, dung, and urine are considered valuable for many religious and therapeutic purposes. One elderly person said that people in the old days used to donate many cows to their priests and relatives. Nowadays, they got an opportunity of seeing and touching a cow only on the eleventh day (a strict requirement of the Hindu culture) of their parent's death. The holy value of their rivers was also dramatically decreasing as stream water contaminated with pesticides from farm land and sewerage from urban areas polluted the rivers. Some elderly people said that increasing population on riversides and growing use of chemicals in farms turned the river water from holy to profane. Many people had abandoned bathing by river water now.

4.6.4. Amenity and recreation

In response to a question about whether the scenic environment of their communities had changed over three decades people said that huge change had occurred, especially in farming areas. Crop and tree intensifications provided enriched scenic diversity in the landscapes especially during winter and summer seasons. The cropping intensity has been increased mostly in bottom part of the hills and high population density communities. Despite noticeable change in tree density the amenity value decreased with declining cropping intensity in middle to upper belt of the mountain (Fig. 4.4). Livestock had contributed to recreation value especially from grazing in open field and carrying goods and people in difficult terrains. This opportunity has gone with abandonment of the practices.

The mountain agricultural resources provide recreational attraction to the people who are least interested in costly, risky and long-distance activities such as national parks and water sports. Many respondents shared experiences of increasing visits of domestic tourists to their communities. One respondent said that only foreign tourists had made night stay camps and walked through a main trail crossing his community when he was young, but he saw both foreign and Nepalese tourists travelling on the road and stopping at mountain view-points nowadays. Visits of young people from local towns also increased to see their farming based life styles. Some farmers reported that tourists visited their community to watch and took photos of incredible views of the Himalayan peaks above their green landscape's horizon. Some respondents stated that people also visited for film and music making purposes. Revolutionization of computer and digital technologies has increased the demand for, and the uses of, the recreational services of the farming communities. The uses of the amenity resources of the landscapes in films and music industries, social media and online resources might have increased its users both online and using other digital sources and motivated them to make an onsite visit. One tourist said that the development of communication, infrastructure, and social networking facilities made his short visit possible. Higher incomes and changing social values of urban people were hidden factors that increased rural tourism. Homestay facilities also motivated tourists to take recreational advantages of agricultural resources. However, decreasing participation of youth in farming activities has reduced local people's participation in some farming-based mental stress relieving activities such as singing, dancing and other forms of socialization.

5. Discussion and conclusions

The aim of the study was to ascertain the recent state and problems of agricultural landscapes-based resources and their ecosystems services. Table 5.1 summarises the state of ecosystems services and community level effects of changes in atmospheric environmental and biodiversity resources.

Recent changes in farm level resources and practices have mostly reduced emissions and increased mitigation of GHG. The finding of the resources' improvement is similar to other studies such as Marquardt et al. (2016). The finding contradicts the arguments in the wider literature such as Valin et al. (2013) and IPCC (2014) which describe increasing GHG globally from farming sector. Directly farm related activities have ameliorated amenity but the negative changes in ambient environment is caused by road development and downstream pollution which are not directly farm related activities. The situations of natural hazard moderation are similar to the amenity amelioration. This finding is a bit difference from the arguments stated in high level reports (IPCC, 2014) which stated that anthropogenic factors contributed to climate

Fig. 4.4. Amenity differences between high and low intensive farming lands (2003 and 2019).

Table 5.1
Summary of ecosystems services of atmospheric environment and biodiversity resources.

Resource bases/ecosystems services	State	Main effects at community level
1. Atmospheric environment		
Climatic regulation	++	The implication of GHG emission reduction and mitigation was unclear to local people but scientifically it contributed to better living environment.
	+−	
Amenity amelioration	++	Healthy in-house environment, greenery outdoor environment, unpleasant outdoor amenity with dust and hazy sky in summer season;
	+−	fuggy winter sky increased potato blight and coldness to people and livestock.
Hazard moderation	++	Reduced on farm resources casualties and economic loses in many cases;
	+−	Dust from fair weather road polluted foods and water in dry season.
2. Biodiversity		
Plant species diversity	++	New food crop species increased crop yields provided nutritious and tasty vegetables all year round. Invasive species increased cost of
	+−	production and affected crop and livestock production; extinction of locally adaptable nutritious local grain crop species (often called minor crops); and loss of indigenous crop species with special social and nutrition value.
Plant genetic diversity	−−−	Introduced genetics-based crops increased crop yield substantially and reduced farm work burden on women. But they increased risk
	+	complete crop failure; increased risk of pests in extreme climatic conditions; increased external dependency for seed and fertilizer which created greater difficulties for poor farmers; reduced livestock feed; increased postharvest storage quality; vegetable varieties less suitable for home garden purposes; loss of indigenous varieties with special social and nutrition value; loss of crop varieties with local social identity; and hindered local food severity.
Animal species diversity	−−−	Declining to extinction of indigenous species hampered cultural practices and consumption of traditional foods. Few practices with new
	+	species.
Animal genetic diversity	−−+	Exotic breeds increased productivity of animals; increased dependency on grain feed and modern health services for animals; poor
	+	farmers and disadvantaged localities benefited little from exotic breeds/new genetic animals.
Local gene improvement	−	Increased practices of growing externally supplied seeds and reduced handling and storage burden. On the other hand, it hampered in situ conservation practices for improving locally adaptable breeds and varieties;
Habitat conservation	−++	Improved habitat for wildlife and other creatures has increased crop and livestock loss and made it more difficult to do farming work.
	+	Some habitats fostered beneficial species such as honey bee production. Degradation of habitats of some beneficial species (e.g. dung beetle and frogs) reduced their services for crop production and protection.

Note: ++++ = mostly positive changes; −−−− = mostly negative changes; ++ −− = negative and positive changes almost equal; −+++ = some negative and the other positive; +−−− = some positive and other negative.

change and escalated natural hazard problem. The natural disasters which have increased agricultural loss in developing countries overtime, as described by FAO (2015) are little related to local farmers' activities. Field evidences showed declining of farming activities contributing to production of incomplete burnt carbon particles that scientists have considered a growing problem for glacier retreat and related hazards in the Himalayan region (IPCC, 2014; Xu et al., 2009a; Xu et al., 2009b; Venkataraman et al., 2005). However, the positive changes contribute to reduce the effect of the disaster beyond the farmers' control. Regarding end outcomes of the changes in atmospheric environmental conditions, the negative ones look lasting for a season whereas positive ones look lasting for a long period.

External factors effects on biodiversity resources and services are wide ranging. Plant species diversity was hugely increased whereas plant genetic diversity was seriously decreased. Animal species diversity has been decreased and animal genetic diversity has been increased in most communities. Serious setback found in local genetic resources improvement. However, agricultural intensification and plant resources enrichment in both space and time (longer season) have provided habitat for many wild animals and plant species. This finding is contradictory to studies in other regions which have concluded that agricultural intensification hampered biodiversity (Stoate et al., 2009; Zhang et al., 2007; Tscharntke et al., 2005). Degradation of indigenous species and genetic diversities is not by agricultural intensification; it is due to introduction of exotic species and practices. Many conditions in the mountain regions limit the practice of large-scale intensification which has proven destructive for biodiversity in other regions.

The increase in species diversity found many noticeable benefits and some harms to local community. The loss of traditionally practised species has implicit long term social and health effects. Similarly introduced genetic resources have some explicit benefits but many implicit harms. The displacement of local resources, knowledge and local seed management institutions by the introduced genetic resources has hampered local food security, food sovereignty and community heritage. Farmers could not have access the indegenous resources when they got fustration from crop failure and seed shortage in market (Dhakal, 2016). Unfortunately development support agencies have little valued the sensetive social issues while making their interventions to promote modern agricultural practices and services.

Similar phenomena have also occurred with livestock resources. The small-scale livestock farming found seriously declined though the business is an engine as well as inspiration for mountain farmers. The drivers of the decline in small scale livestock farming are not only the resultant of global changes but also by the interventions of national policy and international support agencies for increasing forest and GHG mitigation (Dhakal, 2014; Dhakal et al., 2011). Declining livestock has had had a considerable knock on impact in mountain economies and farming systems: escalating human migration, declining of mountain farming, including abandoning arable land from farming and degradation to extinction of biodiversity resources. The serious degradation of the indigenous resources and practices can result serious consequences for the mountain regions where the geophysical condition is weaker and people living in rugged mountain conditions have frequently been the victims of natural disasters. Government response in recent disaster events (e.g. the 2015 earthquake) has clearly demonstrated that its systems are unable to handle crises, even a medium scale disaster. Nepali people had also suffered from serious economic and huminitarian crises after a few months of Earthquake as India indirectly blocked supplies of daily need goods including seed and fertilizer to make a political demand of its favourite ethnic communities fulfilled. Though the China government had behaved generously in the crisis time, the earthquake had collapsed the road networks to access the goods from China. India has imposed serious economic sanctions to Nepal, a landlocked country for its vested national interests many other occasions such as 1970 and 1989. It infers that the policies and other interventions of the development support agencies have placed the mountain farmers in further vulnerable position to food crises when large scale natural disasters coincide with protracted crisis at transboundary scale. The resources conserved in gene-banks or museums and inputs from external service providers are often inaccessible to local communities during such crises. It is an interesting to note that development agencies (e.g. government, NGOs and international support agencies) have played directly and

indirectly instrumental roles in disappearing the indigenous resources and practices and excerbarating vulnerability but the agencies have given message to the world that they have worked for developing sustainable and stresses resilient farming and economic systems. In the mountain context their interventions resulting the outcomes can be called inexecusable bad agencies practices.

Since the loss of biodiversity resources and declining of mountain livestock business have knock-on negative effects for the functioning of many systems of mountain farming practices, indigenous knowledge and economy, the problem needs to be addressed effectively. A multi-pillar development approach (mixing modern and old systems) would enable the mountain communities to utilize the benefits of risky modern development services while still hedging themselves against critical threats by indigenous resources. These both systems can be practiced together in the mountain context. Most policies and practices of natural resource management in Nepal have been determined by international policy agenda, financial and technical supports and other interventions (policy lobbying and advocacy). Therefore, the emerging social economic and environmental problems in the mountain agricultural landscapes cannot be alleviated unless misunderstanding and bad working practices of the people (technical and policy experts) in related national and international organizations are addressed.

Table 5.2 summarises the state of ecosystems services and community level effects of changes in soil, water and waste-sink resources. Effects on ecosystems services of soil (erosion control, fertility and quality maintenance, and medium formation) resulting from recent changes in soil resources were found to be mostly negative. However, soil erosion found decreasing with agricultural intensification. The finding is contradictory to the findings of other areas where farming intensification increased soil erosion (Faucher et al., 2015). The intensification in the mountain areas reduced the length of soil exposure to erosion agents. The intensification has also occurred mostly in economically high value lands where farmers have responded to erosion problems promptly. It is costly and less motivating to response to soil loss by landslides in low value farm lands. People abandoned farming in such landslide field and escalate food security problem but abandoning farming in arable land reduces soil exposure to eroding agents and soil erosion.

The problems of degrading soil quality, declining soil formation practices and abandoning land from farming are serious issues in the vulnerable mountain communities. They have escalated problems of household food insecurity and mountain community development. For alleviate problems of increasing dependency on imported foods and declining local farming economy, some local governments in the country have proposed monetary fine to the farmers who abandon their arable land from farming. The policy will increase women and elderly's work burden for farming in marginal land. Looking the roots of the problem, conventional agricultural development policies and existing models of external supports may be of little benefit in addressing the complex problems and sustaining the ecosystems services of the lands.

Effects on water related ecosystems services resulting from recent changes in soil resources are also mostly negative. However, changes in water conservation in a catchment is a difficult subject to understand for farmers. In the survey some farmers argued that vegetation intensification might have contributed to water conservation. This conventional wisdom-based argument is difficult to believe because it contradicts experimental studies (Novák et al., 2010; Bruijnzeel, 2004). The trees may have rather increased soil water loss by evapotranspiration process. The external interventions also discouraged traditional tree management and utilization practices (e.g. lopping branches of the forest trees for fuelwood and fodder) which might have aggravated the evapotranspiration problem. The growing tree canopy may suppress understory vegetation that could play an instrumental role in breaking the water runoff speed and improving the soil surface environment for water infiltration. The canopies also block precipitation to be received by land and in-filtered into soil (Bruijnzeel, 2004). Based on

Table 5.2
Summary of soil, water and waste sink related ecosystems services.

Resource bases/ecosystems services	State	Main effects at community level
1. Soil		
Soil erosion	+−−−	Decreasing soil erosion by abandoning land from farming and livestock grazing has reduced top soil loss and sedimentation to downstream areas. Decreasing practices of immediately rehabilitating landslide affected fields has reduced crop production land area and increased knock-on landslides in downstream fields. Soil erosion related to rural road activity has hampered food production due to covering good farming soil by infertile soil, stones and other debris. It has also polluted amenity and crops.
Soil quality and fertility	+−−−	Decreasing local soil fertilizing practices including livestock manuring; increased practice of abandoning farming land and thereby local food production. Loss of indigenous mycorrhiza due to chemical fertilizer; resulting loss of local crop species tolerant in marginal lands and reduced following season harvest in fertilizer shortage year.
Soil formation	+−−−	Declining practices of soil formation increased farming land abandonment and affected food production.
2. Water		
Water recharge and conservation	−−−−	Decreasing opportunity for water recharging and conservation may have some effects in downstream water supply but complicated to measure.
Flood reduction	−−−−	Reduction in flood reduction service of the land has increased flooding intensity downstream.
Water supply	+++−	Increasing water supply in farmland has increased production, especially vegetable crop production, which has contributed to human health. It has also reduced household work burden for women. The diversion of water from original courses to cropping fields has affected wild animals; increased incidence of wild animals in farms including homesteads, and harms to people.
Water quality	++−−	Improvement in water quality by controlling grazing and open toileting practices in fields has reduced frequency of water-borne diseases. Uses of chemicals in crop fields has polluted downstream water for domestic uses and wild animals.
3. Waste		
Decomposition and detoxification	++−−	Human waste application improved soil fertility. Cropping intensification has reduced opportunity to apply contaminated urban waste in urban surroundings. Expansion of rural road network increased opportunity for using urban waste for soil fertilization if applied in safe sites. Growing application of toxic contaminated non-farm wastes in crop fields has increased human and environment health risk.
Sedimentation	−−−−	Decreasing sedimentation control practices and increasing material production especially by road work has restricted cropping areas. It also increased stream load which resulted in land and infrastructural damage in downstream areas in rainy periods.
Indecomposable waste storage	++−−	Shifting practices of storing indecomposable waste from underground onto field surface reduced fields for crop production. Rural road network expansion has increased opportunity of storing such material in marginal lands.

Note: ++++ = mostly positive changes; −−−− = mostly negative changes; ++−− = negative and positive changes almost equal; −+++ = some negative and the other positive; +−−− = some positive and other negative.

the findings of experimental studies intensification of tree vegetation has hampered water conservation service.

The water from natural courses is diverted to other areas which has ensured to make reliable supply to farms and residential areas. Declining availability of drinking water in natural courses has affected some wild animals. It is one of the emerging critical problems which urges urgent policy action. Availability of water throughout the year in residential areas has contributed to thriving populations of some insects and pests. However, previous studies about climate change effects in the community have reported that increasing biotic agents, including the mosquito, over the last two decades is the resultant of climate change (Gentle et al., 2014; Chaudhary and Bawa, 2011). This finding suggests that effect of external factors on ecosystems services in agricultural landscapes can be better explained from the lens of a multiple resources framework.

Waste resources as well as sink areas for management have increased. Decreasing sedimentation services has had a bigger effect on local crop production and the downstream economy. Urban and human waste contains more toxic and harmful materials than the waste of other animals. Scientists recommend applying the compost made from urban and human waste only in orchards and forests where workers and products have minimum direct contact with soil (Clarke and Smith, 2011; Speir et al., 2003). However, development agencies have motivated farmers to apply the resources by verbal persuasion and providing economic incentives indirectly (e.g. subsidies for biogas plant installation). The mountain farmers applied these resources irrespective of crop type, farming practices and environmental sensitivity (e.g. proximity of drinking water sources) of the fields. The hazards of mountain agricultural land get spread more quickly to downstream areas by gravitational forces. The toxic substances affect the reproductive organs especially of women and result in low birth weight, fetal and infant mortality, spontaneous abortion and the occurrence of birth defects (Rushton, 2003; Steingraber, 2001). The action of changing a sensitive social value (use of human excreta for food production) and introducing the risky practices in institutionally weak community and environmentally sensitive area is a serious violation of professional ethnic of the development support agencies. Addressing the socially and environmentally issue of waste management is an important policy agenda.

Table 5.3 shows external factor effects on social ecosystems services and implications for local communities. The impacts on services for maintaining local knowledge system are mostly negative. The finding is similar to other studies (Sharma et al., 2009). The local knowledge is the primary basis for maintaining mountain systems. The loss can be considered a serious issue because the indigenous knowledge system is the main foundation for utilizing local resources and maintaining economic, social and environmental resilience of the mountain communities living in geophysical vulnerable and institutionally disadvantaged areas. Documented knowledge provides little benefits to the vulnerable people in the time of crises. Considering the sensitivity, conservation of indigenous knowledge is an agenda for urgent policy action.

Recent changes in natural resources and farming practices have resulted in a mostly negative impact on spiritual services. In developing societies, the main users of spiritual services are the elderly who are more likely to have mental health problems as they become older. Cultural and spiritual practices keep the elderly busy and bring relief from their mental health problems. It means that the decline of cultural and spiritual services makes the mental health problems of elderly people worse. The amenity and recreational services are mostly increased in the areas where farming intensification is high. Tourists' visits have been surged in the areas. The finding implies that agricultural intensification in mountain farm land could revitalize the mountain farming economy.

The responses of the community regarding to recent changes in the resources' conditions can be understood as follow. Increasing of ES with improving condition of the resources has resulted their better well-being. The people's responses in the vulnerable state of the resources was unclear. Most people had changed behavioural and practices to adapt in shortage of supplies of goods or services of degrading resources. Some people showed coping response due to unavailability of goods or services of the resources in verge of loss and extinct states.

The differences in findings about changes in ecosystems services of natural resources in agricultural landscapes between mountain and other areas implies that blanket environment policies at general may not result desired social and environment effect to the mountain communities. Interestingly, many critical environmental problems in the mountain have been exacerbated by the policies, information, advice and material supports of national and international agencies which have been working on the agenda of preparing vulnerable communities to adapt and cope against extreme natural disasters and protracted crises even at transboundary scales. The findings of this study suggest that the agencies need to review their working policies and practices for supporting the mountain communities.

The above conclusions are based on a study in a catchment which may not be representative of whole country. Similar studies in many other areas may give a better picture of the scale of impacts of the changes in ESs of natural resources in mountain agricultural landscapes and subsequent effects on local communities. However, the approaches used in this study and its findings may provide a useful guide for those future studies.

Table 5.3
Summary of social ecosystems services.

Ecosystems services	State	Main effects at community level
1 Social		
Local knowledge system	−−−−	Declining indigenous knowledge transformation system leading to loss of opportunity to utilize local resources; and increased economic, social and health vulnerability of the poor. It has also hindered conservation of locally economically important plant species.
Cultural	++−−	Loss of locally valuable cultural resources hampered transmission of social identity and legacy. Market driven species with cultural value for some species increased income and employment
Spiritual	−−−−	Declining spiritual related resources hampered spiritual practices, social discipline and ability to treat mental health; socially marginalised elderly and religious people.
Educational	++−−	Increasing numbers of exposure visits and field research activities have boosted social recognition of farmers. Activity hosts often receive financial rewards. Declining educational opportunities and practice of indigenous resources hampered knowledge transfer for conservation of community heritage.
Amenity and recreational	+++−	Increasing of amenity and recreational resources has attracted tourists which has increased income and local employment opportunities. It has also increased popularity and social recognition of local community. Increasing services has played promotional and protective role for some natural resources and cultures.

Note: ++++ = mostly positive changes; −−−− = mostly negative changes; ++−− = negative and positive changes almost equal; −+++ = some negative and the other positive; +−−− = some positive and other negative.

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Declaration of conflict of interest

The authors were grown up and visited regularly in the study site communities. Some information in the text were based on their life experiences. There is no conflict of interest of authors on the content of this manuscript.

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